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Age estimation using three established methods A study on Indian population

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Abstract

Age estimation is an important factor in the identification of an individual in forensic cases. Adult age determination from teeth was carried out using three methods, namely, Johanson method, methods of Kashyap and Koteswar Rao and the average stage of attrition method (ASA). A total of 100 patients were selected. Johanson and Kashyap method uses microscopic measurements, whereas ASA is purely a clinical method. ASA method was found to be the best method. Unsatisfactory results were seen more in Kashyap's technique. In all the three methods overestimates of age were common in mandibular teeth and in teeth taken from female individuals. More studies are needed in Kashyap's method as there are certain difficulties encountered in measuring a few criteria.

Keywords: Forensic odontology; Age estimation; Gustafson method

1. Introduction

Age estimation constitutes an important factor in the identification of an individual in forensic odontology. It is being used in cases where a dead body or part of the body has to be identified, cases in which an individual does not reveal his identity, and in legality of child marriage cases.

Age can be estimated in children and in adolescents by means of development and eruption of deciduous and permanent teeth up to 14 years. For most age estimation methods the developing teeth are subjectively assessed on radiographs. After the age of 14, the third molar is the only remaining tooth that is still developing and consequently dental age estimation methods have to rely on the development of this tooth until the age of 20. After this period age determination is mainly done by visual examination, radiographic methods [9,11], structural changes in teeth and by means of chemical methods [14].

Various parameters have been used by authors for the assessment of age [19,20]. Gustafson in 1947 presented a paper based on structural changes in the tooth [5]. Six changes were taken into consideration. They are attrition, gingival recession, secondary dentin, cemental apposition, root resorption and root transparency. These changes were given scores ranging from 0 to 3 and linear regression equation made for calculating the age. The correlation coefficient obtained was 0.98. The main drawback of Gustafson method was that all the values were given equal importance. Later multiple regression analyses were performed by Dalitz [4], Johanson [7], Burns and Maples [2], and Maples [13]. Johanson method was better compared to others. Kashyap [8] used objective type of measurements and showed improved results. Recently, improved statistics were applied to the Gustafson method for better results [12].

The radiographic method wherein the ratio between the pulp chamber and tooth is calculated is also found to be promising [11]. Colour of the teeth is another criterion in age estimation. Although it is difficult to obtain an objective measurement, Solheim [17] recently showed a strong relationship between colour and age.

Measurements of attrition have also been advocated as age parameters [15]. The most reliable method in attrition is the one developed by Li and Ji [3]. Here, the average of attrition level of all the cusps was taken and a new graduation standard established. Cemental annulation lines have also been used as a criterion for age assessment [10].

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Although the science of forensic odontology has emerged near its height at the global level, this speciality has not developed or evolved as a subject in India. This is evident from the fact that there have been very limited studies conducted on the Indian population. Forensic medicine specialists are often not well versed with intricacies of dental sciences.

The present study was undertaken to utilise the different methods of age determination on the Indian population. Another aim behind this study was collection of baseline data for establishing a forensic odontology centre in our country.

2. Materials and methods

A total of 100 patients were selected from the Department of Oral medicine and Radiology, A.B. Shetty Dental College, Mangalore. Ages ranged from 21 to 60 years. Patients were divided equally into four age groups, namely, 21–30, 31–40, 41–50 and 51–60 years. None of the patients had any medical problems or any hard tissue pathologies. They neither had the habit of pan-chewing. Criteria for selection included those individuals who had to undergo extraction of either premolars or anteriors and had intact molar teeth either first or second or both. The reasons for extraction were orthodontic purpose, mobility, and for the fabrication of dentures. A total of 100 teeth were extracted from 100 patients. Three methods were carried out. They were (1) Gustafson technique modified by Johanson (2) Gustafson technique modified by Kashyap and Koteswar Rao and (3) average stage of attrition (ASA) method. Age, sex and address of the patients was re corded by a member of the teaching staff, and all the patients as well as corresponding teeth were given code numbers. Two examiners carried out the measurements. The results were subjected to regression analyses using the statistical package for social sciences (SPSS) software.

2.1. Gustafson method modified by Johanson

A total of 100 extracted teeth were used for this study. All the extracted teeth were devoid of any pathologies. Before extraction the amount of gingival recession was noted according to the Johanson's chart [7]. The extracted teeth were made into 0.25 mm thick ground sections, and mounted on glass slide using Canada balsam. These sections were viewed under a microscope for criteria like attrition, secondary dentin, cemental apposition, root resorption and root transparency. All these criteria were given scores according to the Johanson's chart [7]. Using statistics, linear as well as multiple regression equations were made for age estimation. The linear regression equation used was, age $= 18.34 + 3.39X$; multiple regression equation was, age $= 19.61 + 3.01S + 1A + 2.97C + 5.65P + 1.71R + 4.94T$; where A is the attrition, S the secondary dentin, P the gingival recession, C the cemental apposition, R the root resorption, T the root transparency. Standard deviation (S.D.) of linear regression equation obtained was ± 5.9 and that of multiple regression equation was ± 5.5.

2.2. Gustafson method modified by Kashyap and Koteswar Rao

The earlier made ground sections were viewed under a microscope having a measuring table of 10 μm accuracy. The criteria namely attrition, secondary dentin, cemental apposition and root transparency were objectively measured. Each criterion was divided by constant parameters present on the teeth namely width of the crown, length of the root canal, width of the root and length of the tooth, respectively [8]. From these values percentages were calculated and index values were obtained [8]. Using multiple regression analysis age was estimated. The equation obtained was, age $= 21.57 + 0.08[A] + 0.18[C] + 0.33[D] + 0.5[T]$; where $[A]$ is the index value of attrition, $[D]$ the index value of secondary dentin, $[C]$ the index value of cemental thickening, $[T]$ the index value of root transparency. S.D. of the equation was ± 5.4.

2.3. Average stage of attrition method

Attrition method is a clinical method where the attrition of molar cusps is recorded. Attrition value of each cusp is taken following which the average is calculated. The scorings for attrition were done by using ASA chart [3]. From these values separate equation for the first molar, the second molar and for both the molars were made. Separate equations were again made for both maxillary and mandibular teeth. And the age were calculated. The equations are as follows (as there were no cases with maxillary second molar alone no equation was made for that tooth).

- For maxillary teeth

first molar : age $= 36.39 + 1.93M1$

both first and second molars : age $= 25.99 + 2.09M1 + 1.39M2$

- For mandibular teeth

first molar : age $= 24.58 + 3.78M1$

second molar : age $= 22.16 + 4.26M2$

both molars : age $= 20.08 + 2.46M1 + 2.15M2$

3. Results

Results showed that in all the three methods the mean errors were almost close to zero in both the examiners (Table 1). When we see the S.D. of errors, it is most favourable for ASA method and least for Kashyap's method. Finally, the range of errors again suggests that ASA is the most reliable method and incorrect results are found more with the methods of Kashyap (Table 1).

Table 1
Dental age estimation by three different methods

Methods	Mean error		S.D. of errors		Range of errors	
	Examiner-1	Examiner-2	Examiner-1	Examiner-2	Examiner-1	Examiner-2
ASA	−0.14	−0.11	2.58	3.32	−7.06–6.17	−7.52–9.78
Johanson	−0.60	−0.78	4.61	4.07	−11.01–13.1	−11.01–9.7
Kashyap	−0.02	−0.10	5.85	4.16	−14.19–15.7	−10.76–15.7

Table 2
Dental age estimation by three different methods[a]

Methods	Excellent	Acceptable	Unsatisfactory
ASA	78	22	0
Johanson	54	43	3
Kashyap	34	56	10

[a] Percentage of age estimates with error <±3 are excellent; with error <±10 are acceptable and error <±15 are unsatisfactory.

Table 5
Dental age estimation by three methods[a]

Methods	Age groups (years)			
	21–30	31–40	41–50	51–60
ASA	−1.66	0.21	−0.14	1.04
Johanson	−3.11	−1.35	0.8	1.28
Kashyap	−3.46	−0.09	0.87	2.6

[a] Mean of the error in years in different age groups.

Percentages of errors were grouped according to their magnitude (Table 2). Errors <±3 years are considered excellent, while errors <±10 years were considered acceptable for forensic investigation. Errors <±15 years were regarded unsatisfactory. Excellent results were most frequent with ASA method followed by Johanson. There was no unsatisfactory result with ASA method. Kashyap's method dominates with most of the unsatisfactory results.

The individual criteria showed (Table 3) that S.D. for root transparency is most significant in both the methods of Johanson and Kashyap. Root resorption found least favourable in Johanson's method, whereas in Kashyap's method it was the cemental apposition.

The regression equation S.D. in ASA technique (Table 4) ranges from ±2.8 to ±3.9 years. When we use mandibular second molar alone the S.D. is more but that of mandibular first and second molar it is very less.

In the age group-wise analyses all the three methods showed predominance of underestimates among <40 years whereas overestimates were seen mostly after 40 years (Table 5). Mandibular teeth showed overestimates of age in all the methods and higher tendency to overestimate age in female individuals (Figs. 1 and 2).

Table 3
S.D. of individual criteria in different methods

Criteria	S.D.	
	Johanson method	Kashyap method
Attrition	9.8	10.3
Gingival recession	9.6	Not applicable
Secondary dentin	8.9	7.7
Cemental apposition	11.1	10.4
Root resorption	11.5	Not applicable
Root transparency	8.3	6.2

Table 4
Average stage of attrition method: S.D. of regression equations

Tooth used	S.D.
Maxillary first molar	3.9
No maxillary second molar used	–
Both maxillary first and second molar	2.98
Mandibular first molar	3.47
Mandibular second molar	3.94
Both first and second molar	2.76

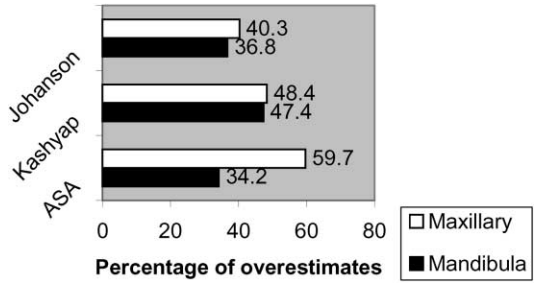

Fig. 1. Percentage of age estimates according to three different methods which resulted in over estimates in maxillary and mandibular teeth.

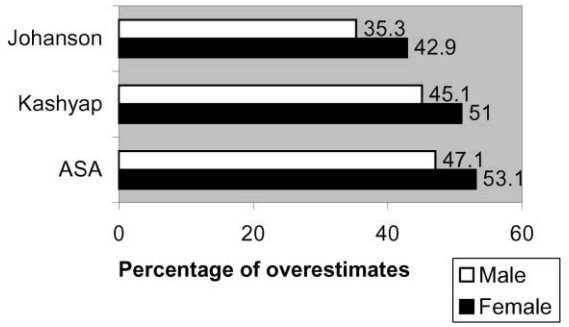

Fig. 2. Percentage of age estimates according to three different methods which resulted in over estimates in males and females.

4. Discussion

Age determination from teeth is a field within forensic odontology that is of great interest for the odontologist in his work on identification. As with the whole human body, the teeth show changes with age. Some changes are seen directly at inspection of the mouth, others are only seen under the microscope. It has been shown that the state of the teeth has a closer correlation with age than any other hard tissue of the body. A study was planned to utilise various methods available for evaluating the morphological, structural and microscopic changes in teeth that correlate with age.

The Gustafson technique is the most popular age estimation test being used since 1950 [6]. It uses six regressive changes in the tooth, namely, attrition, secondary dentin, gingival recession, cemental apposition, root resorption, and root transparency. This technique was modified in many ways by many authors to get optimum results [18], Johanson applied multiple regression analyses and changed the scoring system. He did this study in 165 teeth. We applied his method in 100 teeth and obtained a S.D. of ± 5.5 years (Table 3), using multiple regression equation. As Johanson [7] showed we got a better result using multiple regression than using linear regression equation. The above age range indicates that age can be predicted within ± 5 years from the actual age. Our results were comparable to that of the original study, where Johanson obtained a S.D. of ± 5.16 years. Of the six criteria used root transparency is the most reliable [1] and root resorption is the least dependent in both the Gustafson modifications. These observations were also similar to that of Johanson's original work.

Kashyap modified the Gustafson technique by using objective measurements and omitted criteria like gingival recession and root resorption. S.D. obtained in Kashyap method was ± 5.4 years (Table 3). In the original study, Kashyap and Koteswar Rao [8] arrived at a S.D. of 1.6 years. It shows there is a 3 years difference in age between our study and that of Kashyap's work. This difference is mainly attributed to the difficulty in measuring the length of secondary dentin and width of cemental apposition. Kashyap's study takes the length of secondary dentin formed in the pulp space and width of cementum formed at the side of the root. In our study we observed that in some cases secondary dentin length is almost similar in different age groups. Tencate [16] showed that secondary dentin deposition takes place along the wall of the pulp canal, so it is preferable to take overall quantity of secondary dentin than taking the length alone. In the case of cemental thickening it was found that cemental apposition takes place more at the apex. In a number of cases cemental apposition in different age group was similar but the overall thickness increases with age. Tencate [16] too had the same opinion. We adhered to the criteria given by Kashyap and followed his method of measurements in both secondary dentin and cemental apposition. We believe that further studies are needed in Kashyap's method because of the above observations.

When we see the mean errors and range of errors we realise that method of Kashyap is inferior to Johanson. The number of unsatisfactory results with Kashyap gave an indication that it is better to use Johanson method compared to Kashyap. The increased unsatisfactory results with Kashyap may be directly related to the difficulty in obtaining secondary dentin and cemental apposition measurements.

The Average stage of attrition method is a clinical technique. Each molar cusp was given a certain score and averages of all the cusps were taken. Separate equations were made for each type of tooth. The S.D. ranged from 2.7 to 3.9 years (Table 4). Li and Ji [3] showed a maximum S.D. of 4.5 years. This suggests that our study is an improvement on previous works. Reasons for this could be our criteria of patient selection; we had taken patients with intact molars and who had no history of pan-chewing. But individual variation can affect the attrition status. This method has great forensic value because of its accuracy in result, its convenience in use and its ease in understanding. Dental attrition is population specific, and we have shown that the ASA method is suitable to an Indian population.

Observation of mean errors, S.D. of errors and range of errors indicates that best method out of the three is ASA method. In our study selection criteria we followed in the ASA method must have influenced its better results. Whereas in methods of Johanson and Kashyap regressive alterations of teeth were taken into consideration. So there are bound to be some individual variations. Since the Johanson method uses more number of criteria than Kashyap, it would have resulted in its better correlation with age compared to the methods of Kashyap. It was as suggested by Solheim [17]. Objective type of measurements has the advantage over subjective type of measurements. Findings by both the examiners were almost similar, pointing to the fact that subjective type of measurements has not influenced the results and evaluation of them still be considered fairly objective.

In the present study the skewed distribution of the errors as regards to age, sex and jaw shows that the formulae used did not suit these materials. Previous methods also showed errors in different age groups. Teeth from female individuals

showed overestimates in all the three methods. Similarly, mandibular teeth had shown overestimates than maxillary teeth. These findings are contradicting the observations of the previous studies [7,18].

5. Conclusion

Out of the three methods used, average stage of attrition method was found to be the best. But it depends on many dietary habits of the population. The Gustafson modification by Kashyap was slightly superior to Johanson method. And there should be further studies needed on Kashyap method as there are certain difficulties in measuring secondary dentin deposition and cemental apposition. Out of the six regressive changes root transparency is the most reliable criteria. So age determination using the above methods can be tried in forensic cases in the identification of individuals with no birth records.

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